AMENDMENTS TO THE SPECIFICATION:

Page 4, amend the paragraph beginning at line 24 and continuing to page 25, line 5 as follows:

However, this resource allocation can in most cases be performed by ~~means of~~ several different allocation procedures. A problem ~~with the prior art solutions is~~ then is how to select which allocation procedure to employ, but also how to select which link to be affected by the resource allocation, in the case of a choice between different procedures and/or links that leads to the same end-result. For example, some resource allocation procedures, such as channel down-switch, require rather extensive signaling and handshaking between the sender and the receiver and consequently require a long time before the allocation becomes effective. Other resource allocation procedures do not require handshaking and therefore have a relatively shorter execution time. This scenario is exemplified in Fig. 1.

Page 6, amend the paragraph beginning at line 3 as follows:

~~A typical prior art~~An allocation unit or system is generally adapted ~~for~~to always ~~employing~~employ a fast resource allocation procedure, if available. With reference to Fig. 1, this corresponds to selecting a fast allocation procedure at time t_0, i.e. the transition from state A to B. However, it might then be possible that the subsequent resource allocation, i.e. from B to D, is time critical. Since now only slow procedures are available according to Fig. 1, system instability might occur if the resource demand becomes too large before the slow allocation is completely executed.

Page 6, amend the paragraph beginning at line 12 as follows:

The present invention overcomes these and other drawbacks ~~of the prior art arrangements~~.

Page 6, amend the paragraph beginning at line 14 as follows:

It is a general object ~~of the present invention~~ to provide an efficient resource management in communications system.

Page 6, amend the paragraph beginning at line 16 as follows:

It is another object ~~of the invention~~ to provide a dynamic resource allocation in communications system.

Page 6, amend the paragraph beginning at line 18 as follows:

Yet another object ~~of the invention~~ is to provide a resource allocation that maintains the possibility of employing fast resource allocation procedures.

Page 6, amend the paragraph beginning at line 20 as follows:

A particular object ~~of the invention~~ is to provide a resource allocation that does not increase a packet delay experienced by streaming users above guaranteed quality of service (QoS) levels.

Page 6, delete the paragraph beginning at line 23 which starts with "These and other."

Page 7, amend the paragraph beginning at line 1 as follows:

Briefly, the ~~present invention~~technology described in this application involves resource allocation in communications system. ~~According to the invention, the~~A pool of resources

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provided by the communications system, or a portion or a sub-system thereof, is divided into different resource classes based on an associated characteristic allocation time. Thus, resources from a given class can be allocated by one or several resource allocation procedures having a characteristic execution time. Correspondingly, resources of another resource class can be allocated by one or several other allocation procedures having other characteristic execution times. The characteristic allocation or execution time then corresponds to a total time from the triggering of a particular allocation procedure to the completion of the allocation. It may be possible that there is only one allocation procedure available for a given resource class. However, it may be possible to allocate resource of a certain class by means of several different allocation procedures, where these procedures have approximately the same allocation time or speed. Furthermore, the resources are divided into multiple classes, i.e. two or more classes, with different associated allocation times.

Page 8, amend the paragraph beginning at line 8 as follows:

In a preferred <u>example</u> embodiment ~~of the invention~~ this selective allocation triggering is performed by comparing the resource utilization measure of the current class with an associated threshold. If the measure then exceeds the threshold, a resource allocation is initiated.

Page 8, amend the paragraph beginning at line 20 as follows:

The advantage of dividing resource into different classes ~~according to the invention~~ and investigating and possibly allocating each resource class individually is that the possibility for the communications system of always having a pool of fast resource available for allocation increases. This means that the communications system most often, and preferably always, has access to a fast resources allocation procedure to use when the total resource utilization in the

system becomes too large. Thus, when resources become scarce, the available fast allocation procedures can be triggered for quickly releasing some resources and thereby avoid the risk of system instability.

Page 10, amend the paragraph beginning at line 3 as follows:

~~According to the invention~~Accordingly, a fast resource allocation procedure is then temporarily employed for releasing resources from a user that presently is provided a guaranteed amount of resources, e.g. reducing available transport blocks to a level below the guaranteed one. As a consequence, the system will temporarily deliver a less-than-guaranteed amount of resources to a user. Once the slow allocation procedure is completed, the amount of resources allocated to this user may the increased, e.g. by releasing a previously imposed TFC limitation. Thus, although a user at a certain moment may be provided with less than guaranteed amount of resources, the average resource amount provided over time to that user is at least according the guaranteed level.

Page 10, amend the paragraph beginning at line 14 as follows:

This example embodiment of temporarily reducing the bit-rate (through use of TFC limitations) may result in breaking QoS contracts, in particular for streaming users, since the reduced transport bit-rate leads to data being accumulated in the sender's buffer and therefore to increased packet delay. By monitoring the total packet delay and the delay originating from TFC limitation for different users, imposed TFC limitations may be released (if the delays become too large) before QoS contracts are broken.

Page 10, amend the paragraph beginning at line 21 as follows:

The ~~invention~~technology offers the following example advantages:

Page 11, amend the paragraph beginning at line 3 as follows:

Other advantages offered ~~by the present invention~~ will be appreciated upon reading of the below description of the example embodiments ~~of the invention~~.

Page 11, delete the paragraph beginning at line 6 which starts with "The invention together."

Page 11, amend the paragraph beginning at line 11 as follows:

Fig. 2 is a flow diagram of an embodiment of a resource allocation method ~~according to the present invention~~;

Page 11, amend the paragraph beginning at line 15 as follows:

Fig. 4 is a schematic overview of an example of a communications system ~~according to the present invention~~;

Page 11, amend the paragraph beginning at line 17 as follows:

Fig. 5 is a time diagram illustrating the lapse of resource measures ~~according to the invention over time~~;

Page 11, amend the paragraph beginning at line 19 as follows:

Fig. 6 is a time diagram illustrating lapse of a resource measure ~~according to the invention~~ over time;

Page 12, amend the paragraph beginning at line 1 as follows:

Fig. 8 is a diagram illustrating the division of resource into different resource classes ~~according to the present invention~~;

Page 12, amend the paragraph beginning at line 3 as follows:

Fig. 9 is another time diagram illustrating the lapse of resource measures ~~according to the invention~~ over time;

Page 12, amend the paragraph beginning at line 9 as follows:

Fig. 12 is a block diagram schematically illustrating a resource allocation system ~~according to the present invention~~; and

Page 12, amend the paragraph beginning at line 18 and continuing to page 13, line 2 as follows:

In the present description the expression "resource allocation" refers to both resource allocation and reallocation and to resource pre-emption discussed in the background section, unless otherwise specified. Thus, in order to facilitate understanding ~~of the invention~~, resource allocation is used throughout the description, also for traditional resource pre-emption and reallocation. Note that~~, according to the present invention,~~ a resource allocation procedure can be used for allocating more, i.e. assigning, recourses to one or several services, links and connected user equipment. Furthermore, a resource allocation procedure can also be used for reducing the amount of resources for one or several services, links and connected user equipment.

Page 13, amend the paragraph beginning at line 3 as follows:

~~According to the present invention the~~A pool of available resources provided by a communications system, or a portion or a sub-system thereof, is divided into different resource classes or types based on an associated characteristic allocation time or speed. In other words, different resources may be allocated by different allocation procedures, where each procedure has a characteristic execution time. This time corresponds to a total time from the triggering of the particular allocation procedure to the completion of the allocation. It may be possible that there is only one allocation procedure available for a specific resource class. However, it may be possible to allocate resource of a certain class by means of several different allocation procedures, where these procedures have approximately the same allocation time or speed. Furthermore, the resources are divided into multiple classes, i.e. two or more classes, with different associated allocation times.

Page 14, amend the paragraph beginning at line 15 and continuing to page 15, line 4 as follows:

Fig. 2 illustrates a resource allocation method~~ according to the present invention~~. The method starts with step S1, where the available resources are divided into different resource classes based on the allocation or execution time (speed) for the allocations procedure(s) that can be employed for respective class, which was discussed above. The method then continues by performing the steps S2 and S3 for each resource class. In step S2, a resource utilization measure is determined for the current class. This measure preferably corresponds to or is based on the total amount of resources utilized in the communications system for the current class, and possible the amount of utilized slower resources. A typical example of such a measure is the

amount of power that may be allocated by procedures of the current class. In a radio communications system, by the "amount of power" is understood an estimate of the average power, where the average is considered, for example, over a radio frame. For example, in the case with one fast resource class and one slow resource class, the measure associated with the slow allocable class corresponds to the amount of power allocable with slow procedures. However, the measure associated with the fast allocable class preferably corresponds to the amount of power allocable with both slow and fast procedures. This principle may be applied also to the situation with more than two resource classes.

Page 16, amend the paragraph beginning at line 5 as follows:

According to a preferred example embodiment ~~of the invention~~ steps S2 and S3 are preferably first performed for the resource class having the longest allocation time. The method then continues by repeating the steps S2 and S3 for the class with the next second longest allocation time and so on, ending with the class with the shortest allocation time. Since the characteristic allocation times for the classes differ, several allocation procedures may run parallel for the different classes. For example, if the utilization measure of a slow resource class is too large, a slow resource allocation procedure is triggered on the resources of this class. If the utilization measure of a fast resource class also is too large, a fast resource allocation is initiated with at least one of its fast procedures. If the execution time of the slow procedure is large enough, the fast allocation is triggered and possible also ended before the slow allocation is completed. In other words, the fast allocation procedure may be triggered and ended during the progression of the execution of the slow procedure.

Page 16, amend the paragraph beginning at line 19 as follows:

The advantage of dividing resource into different classes ~~according to the invention~~ and investigating and possibly allocating each resource class individually is that the possibility for the communications system of always having a pool of fast resource available for allocation increases. This means that the communications system most often, and preferably always, have access to a fast resource allocation procedure to use when the total resource utilization in the system becomes too large. Thus, when resources become scarce the available fast allocation procedures can be triggered for quickly releasing some resources and thereby avoid the risk of system instability.

Page 16, amend the paragraph beginning at line 28 and continuing to page 17, line 15 as follows:

The resource allocation method ~~according to the invention~~, or more precisely step S2 and step S3 of Fig. 2, is preferably executed when the resource utilization or demand in the communications system becomes too large. This may be due to one or several triggering events including changes in the number channels or links used in the system, the number of users connected to the system or the number of services per user. Furthermore, a change in the quality of services (QoS) requirements of an on-going service may result in a too large increase in resource utilization. Reception of updated measurement reports on e.g. mobility and interference changes in the system could be another triggering event. Also changes in the channel characteristics due to completion of a previously initiated procedure, for example a channel switch, and changes in the data traffic (this could be viewed as an external trigger, for example when measurements of sender buffer size or throughput are received, but could alternatively be

viewed as a periodically triggering event, for example investigating whether to trigger allocation per radio frame in a radio communications system) could be a trigger~~ according to the invention~~. The resource demands may also change dynamically, as was discussed in the background section.

Page 17, amend the paragraph beginning at line 16 as follows:

Fig. 3 is a flow diagram of an <u>example </u>embodiment ~~of the invention ~~illustrating the steps S2 and S3 of Fig. 2 in more detail. In the figure, N corresponds to the number of resource classes that are to be affected by the allocation method~~ of the invention~~. This number N is equal to or larger than two. Note that it in some applications could be possible to have one or several resource classes that are not to be allocated with the allocation method~~ of the invention~~. In such a case, these "additional classes" are not included in the number N.

Page 19, amend the paragraph beginning at line 19 and continuing to page 20, line 4 as follows:

In the following, the ~~invention~~<u>technology</u> will be exemplified by a mobile radio communications system providing radio resources to connected mobile user equipment or mobile units. However, the ~~invention~~<u>technology</u> is not limited thereto, but can be applied to other types of systems and/or resources. Thus, the resources can be used for providing communications services on links between a general sender and a general receiver. In a typical situation, the sender is a base station or another network node of a communications system providing (radio) resources to connected mobile units. However, the resources could alternatively be employed for communication between base stations or network nodes between different systems and/or within one system. Thus, in a general case the present ~~invention~~<u>technology</u> can be applied to a system

comprising a node with a limited amount of resources that are assigned to connections with other units. This node could be a wireless access point, e.g. base station, but also other types of nodes, including routers in wired or wireless communications system. These other units can be viewed as "end" nodes or terminals in system.

Page 20, amend the paragraph beginning at line 5 as follows:

In Fig. 4 a mobile radio communications system 1 ~~according to the present invention~~ is illustrated. The communications system 1 comprises a resource allocation system or unit 100 arranged in one or several network nodes of the system 1 and is adapted for managing resource allocation. This allocation system 100 performs the portioning of radio resources from a common pool of resources, schematically illustrated by 200, to different services 402; 412, 414 and different connected mobile units 400; 410. The system 100 also selectively triggers resource allocation when the available radio resources become scarce.

Page 20, amend the paragraph beginning at line 23 and continuing to page 21, line 3 as follows:

The allocation system 100 typically receives input data and information 300 from other units 310; 320; 330; 340 in the communications system 1. For example, the allocation system 100 receives information of QoS requirements 340 of the services, a current resource allocation 330, execution time (speed) of available resource allocation procedures 320 and additional configuration settings 310, which are discussed in more detail below. These inputs can be databases 310; 320; 330; 340 implemented, for example, as registers in the system 1. The input data 300 can be used for determining when to initiate a resource allocation method ~~of the~~

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~~invention~~ and if an allocation procedure is to be triggered, which resources, links, users and/or services to select for the allocation.

Page 21, amend the paragraph beginning at line 21 and continuing to page 22, line 12 as follows:

For increasing the understanding ~~of the invention~~, an exemplified allocation scenario will now be described for a UMTS system with reference to Fig. 5. In this example the resource of interest are the downlink carrier power (total downlink power). This should merely been seen as a typical resource example. In general, the principles ~~of the invention~~ can be utilized also in the power management on the uplink. This may be especially important in a scenario with multi-RABs on the uplink, because this increases the probability for services with different QoS requirements to be handled at the same time. The same principle could also be used also when it comes to other resources, such as the uplink interference measured by the system. However, most of the actions that the system can take to reduce the uplink interference require handshaking with the mobile user equipment. As a consequence, the difference in the execution times of the available allocation procedures (typically channel switch and handover to another carrier or to another system) is smaller. This means that the quantitative gain would be somewhat less.

Page 23, amend the paragraph beginning at line 5 as follows:

According to ~~the invention and~~ the discussion in connection with Fig. 2, the allocation system triggers execution of fast and slow resource allocation procedures depending on the level of the fast and slow resource utilization measure, respectively. Fast (slow) measure should be interpreted as the resource utilization measure associated with the fast (slow) resource class. In

this example the slow measure is the amount of power that may be allocated only by slow allocation procedures, whereas the fast measure is the total downlink power. Consider, also for the sake of simplicity that the triggering criterion is a simple comparison with thresholds T_{SLOW} and T_{FAST}.

Page 25, amend the paragraph beginning at line 25 and continuing to page 26, line 10 as follows:

At moment t_4, the 128 kps to 64 kps dedicated channel switch is completed and the average power used by the Web browsing user is 6 W. The user is still provided with 64 kps, so that the QoS for this user is not affected by the executed allocation procedure. Note in Fig. 5 that the execution time ($t_5 - t_4$) for this slow procedure is much longer than a corresponding execution time ($t_2 - t_1$) for the fast procedure. Since TFC limitations are allowed, according to the operator configurations, to reduce the bit-rate to 0 kps, the amount of slow allocated resource for the Web-browsing user is at t_4 equal to $6 \times \frac{0}{64} = 0\ \mathrm{W}$. (However, this assumption is a simplification used in this example for the sake of simplicity. In practice, the amount of slow allocated resources is larger than zero due to the associated control channel that consumes some resources. But, as previously mentioned, the exact way to estimate the amount of resource to be used by a channel in different circumstances does not affect the principles ~~of the invention~~described in this case). Thus, the slow resource utilization measure is 3 + 0 = 3 W and the fast resource utilization measure is 3 + 6 = 9 W.

Page 27, amend the paragraph beginning at line 19 and continuing to page 28, line 3 as follows:

According one aspect~~ of the invention~~, the resource allocation method may be augmented with a triggering mechanism that allocates resources without waiting for an explicit request for increased resource allocation. For example, with reference to Fig. 5, TFC limitations are used to limit the total power utilization during the link admission process, in order to avoid the unacceptable increase of the average total downlink power during this transitory period ($t_7 - t_5$). At moment t_7, the fast resource utilization monitor (total downlink power) is below its associated threshold of 13 W and it would be possible to remove the TFC limitation imposed on the Web browsing user. In such a case, the user is allowed to utilize up to 64 kps. Since this operation is the reverse of the TFC limitation, their execution times are similar, i.e. removing an imposed TFC limitation is also a fast resource allocation procedure. When this resource assigning procedure is completed at moment t_8, the fast measure is 4 + 6 = 10 W.

Page 29, amend the paragraph beginning at line 17 as follows:

Fig. 7 illustrates the above-described additional steps of the resource allocation method~~ of the present invention~~. If the measure of the current class does not exceed the first threshold T_k, as determined in step S13 in Fig. 3, the method continues to the additional step S17. Here it is investigated whether the measure is below a second threshold h_k*T_k. If the measure exceeds this second threshold the method continues to step S16 in Fig. 3. However, if the measure is smaller than h_k*T_k more resources of the current class can be allocated to connected user, e.g. by imposing an earlier imposed resource utilization limitation, in step S18. The method then continues to step S16 in Fig. 3.

Page 29, amend the paragraph beginning at line 27 and continuing to page 30, line 2 as follows:

A (automatic) threshold setting procedure can be employed for setting the values of some of the threshold values employed for the different resource classes. In a preferred <u>example</u> embodiment ~~of the invention~~ only one threshold is explicitly set, while the other thresholds are (automatically) determined based on this threshold.

Page 31, amend the paragraph beginning at line 21 as follows:

As was discussed above, the resource allocation system ~~of the invention~~ can be configured in such a way that in certain circumstances it is not allowed to execute a specific resource allocation procedure, even if this procedure would be practically possible. The reason why such an available procedure is not allowed to be used could be the QoS requirements or that a certain system behavior is desired. For example, if the bit-rate currently provided to a service already is as low as the guaranteed bit-rate, an allocation procedure that further reduces the bit-rate is not allowed, although it might be available.

Page 32, amend the paragraph beginning at line 16 as follows:

If the slow resource utilization measure exceeds the threshold associated with the fast class, the only way to reduce the total resource consumption below this threshold is to wait for the completion of one or several slow resource allocation procedures, since no fast procedures may be employed (the pool of fast allocable resources is zero) to avoid the congested situation. In this case only guaranteed resources are left for allocation, see 600 in Fig. 8. This unfavorable situation may be coped with according to another aspect ~~of the invention~~. In this aspect, allocation procedures that otherwise would not be allowed are temporarily used, i.e. the

guaranteed resources are (re)allocated. In the general case, if the measure associated with the i-th resource class exceeds the threshold of the j-th class ($j>i$), then procedures belonging to the classes $i+1$ to j, that otherwise are not allowed to be used due to configuration and/or QoS reasons, may temporarily be employed for reducing the actual resource utilization during progression of the triggered resource allocation procedure of class i.

Page 34, amend the paragraph beginning at line 1 as follows:

Meanwhile, the increasing trend continues until the slow measure exceeds at moment t_2 the threshold of the fast resource class. According to the configuration, TFC limitation (fast allocation procedure) cannot be used to permanently release resources in this case (compare with exceeding the max limit in Fig. 8). However, ~~according the invention,~~ resources can temporarily be released (allocated) from the fast resource class. Thus, TFC limitation is used to reduce the bit-rate of the streaming user from 48 to 32 kps. Thereafter the streaming user only utilizes

$$4 \times \frac{32}{64} = 2\ \mathrm{W}.$$

Page 35, amend the paragraph beginning at line 3 as follows:

When using this aspect ~~of the invention~~ of temporarily employing non-allowed resource allocations, there is a risk that the quality provided to the users becomes lower than the desired values. For example, in UMTS, the QoS requirements may become lower than the values contracted through the RAB attributes. In the following the ~~present invention~~description will be exemplified, but not limited to, the management of streaming services. However, the teaching could alternatively be applied to other forms of services.

Page 35, amend the paragraph beginning at line 10 as follows:

In this example, the idea is to monitor the packet delay for the streaming user that has been affected by a non-allowed resource allocation procedure. The reason for this is that a reduced transport bit-rate results in data being accumulated in the sender's buffer and therefore to increased delay. According to this aspect~~ of the invention~~, the bit-rate limitation associated with the temporary resource allocation is ceased (i.e. the initial bit-rate is restored, or another higher than this initial bit-rate is provided) when the delay threatens to exceed the maximum delay attribute in the QoS contract.

Page 35, amend the paragraph beginning at line 25 as follows:

For a better understanding of this aspect~~ of the invention~~, an implementation for UMTS systems is described in the following.

Page 39, amend the paragraph beginning at line 20 and continuing to page 40, line 2 as follows:

Fig. 12 is a schematic block diagram of a resource allocation system or unit 100 ~~according to the present invention~~. The system 100 comprises an input and output (I/O) unit 110 adapted for conducting communication with external units in the communications system. In particular, this I/O unit 110 is adapted for receiving input information and data, which is used by the system 100 for performing an efficient resource management. In addition, the I/O unit 110 is adapted for transmitting resource portioning or allocation commands to a resource portioning unit that performs the actual portioning of resources for different services, links and connected end terminal (user equipment) for the communications system if such portioning unit is not provided in the allocation system 100. The I/O unit 110 may also send information of possibly

triggered allocation procedures to an external allocation database 330, thereby allowing updating data of a current resource allocation.

Page 41, amend the paragraph beginning at line 26 and continuing to page 42, line 21 as follows:

The units 110, 120, 130, 140, 150 and 170 of the resource allocation system 100 may be provided as ~~software,~~date processing hardware alone or ~~a~~in combination ~~thereof~~with software. The units may be implemented together, e.g. in a single network node in the communications system, such as in a node in a base station system. Alternatively, a distributed implementation is also possible with some of the units provided in different network nodes of the communications system. For a radio communications system, the resource allocation system 100 could be provided in a Radio Network Controller (RNC), such as in a Drift RNC (D-RNC), a Controlling RNC (C-RNC) and/or a Serving RNC (S-RNC). As these units are traditionally employed for e.g. controlling radio resource allocation, data-flow control, congestion and admission control in radio communications, the resource allocation system 100 is preferably in a common RNC unit having the functionality of the traditional D-RNC, C-RNC and S-RNC units, or a common D-RNC and S-RNC unit, or in one, some or all of D-RNC, C-RNC and S-RNC. In particular for an embodiment of the resource allocation system 100 that is adapted for managing (restricting or increasing) the number of available transport blocks (TFC), a common D-RNC and S-RNC unit is preferred. In such a case, no inter-unit communications are required between the D-RNC unit, traditionally being employed for monitoring resource allocation and having (a layer three) functionality that considers all links, and the S-RNC unit, traditionally monitoring the data traffic on all links and having RLC – Medium Access Control (MAC) (layer two) functionality. Thus,

TFC manipulating (increasing or reducing the number of available transport blocks) on a downlink channel can be employed as a fast resource allocation procedure for controlling the utilization of another resource type, i.e. average code power or carrier power.

Page 43, amend the paragraph beginning at line 13 as follows:

It will be understood a person skilled in the art that various modifications and changes may be made ~~to the present invention~~ without departure from ~~the scope thereof, which is defined by~~ the appended claims.